

The Nature of Science

What is Science?

How does science work?

- Free movement of ideas no hoarding ideas or keeping secrets
- Observations careful recording / building in repeatability
- Problems identified and solutions attempted

Good vs Bad Science

What is good science?	What is bad science?

The Scientific World View: What scientists believe

The World is Understandable

- No "magic fairies" that irregularly affect natural phenomena
- Science presumes that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study
- Scientists believe that through the use of the intellect, and with the aid of instruments that extend the senses, people can discover patterns in all of nature.

Scientific Ideas Are Subject to Change

- Our understanding is open to new discovery and challenges. Theories must be testable and refutable.

Scientific Knowledge is Durable

- Once demonstrated, ideas may be refined but if discovery is done correctly, relationships will last. Explanations of phenomena may change but observations stand the test of time.

Science Cannot Provide Complete Answers to All Questions

- Spiritual, moral, economic questions.
- Questions that ask "why?" are not scientific
- Questions that ask "how?" are valid.

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Purpose of Scientific Inquiry**Science Demands Evidence**

- Ideas must be backed up with observation.

Science Is a Blend of Logic and Imagination

- Logical ordered relationships between variables may be discovered through imaginative and creative means.

Science Explains and Predicts

- How does this occur. . . and what is likely to occur if . .
- Hypothesis and “trends” provide predictive value

Scientists Try to Identify and Avoid Bias

- Bias removes objectivity and seeks to use scientific ideas for unscientific ends. (Eugenics)

Science is Not Authoritarian

- Does not dictate what to do, what is right or wrong, but provides an explanation of how natural phenomena occur.

Scientific Enterprise

Progression because of a human’s innate curiosity and desire to better understand or manage the environment.

Examples from history of situations that favoured Scientific exploration and opportunities to share ideas publicly

- 1) System of recording and preserving ideas / innovations
 - Library of Alexandria in Egypt (independent of government) accessed by most anyone within the Mediterranean basin
- 2) System by which ideas can travel from one place to another either people move (ideas with them) system of roads or the ideas move (internet) information highway movement of ideas around Europe after 1400s (organised system of roads) restored from the Roman era.
- 3) Beginning of modern Western science dated at founding of the Royal Society in England in 1660
 - First permanent organized community of scientists and scientific journal (Philosophical Transactions of the Royal Society)
 - First permanent written record of experiments performed and conclusions reached

Historical examples of stifled science

- 1) Burning of libraries, books, repositories of learning
 - burning of the Library of Alexandria
 - burning of books in various political movements (Nazism, censorship)
- 2) Silencing / killing of scientists, or people with formal education
 - Bolshevik revolution proletariat elevated /science denigrated
 - Cambodia / "Killing Fields" a society free from the corruption of ideas.
- 3) Restrictions on scientific practice
 - politicisation of knowledge and thus its destruction after a political change.
 - In China at the end of the Ming Dynasty, one of the most marvellous water clocks in the world was developed. It was important so the Emperor could be in sync with the heavens and make proper judgements. Once the emperor died, and the new Dynasty began. In order to ensure loyalty, all of the old calendars were destroyed and new calendars written (the old clocks and other technology were destroyed also).
- 4) Restrictions on travel prevented the movement of ideas around or in and out of a country.
 - Ideas would die with the discoverer, or not be shared beyond an isolated community.

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Experimental vs. Naturalistic Science

Experiments are artificially contrived situations involving direct manipulation and designed for the express purpose of testing some hypothesis

- Requires proper control groups and ideally only a single variable is tested at one time

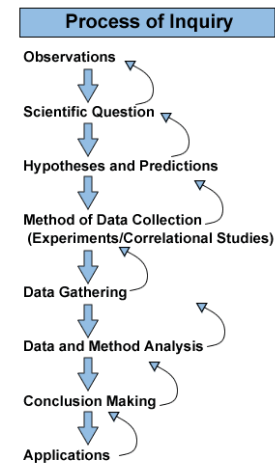
In some cases direct experimental manipulation is impossible or undesirable

- Requires patient observation
 - Animal behaviourists studying mating behaviour under natural conditions
 - Paleontologists cannot go back in time, can only compare fossils to currently existing life forms
 - Astronomers cannot manipulate stars, can only observe them

BOTH REQUIRE CAREFUL RECORD KEEPING**Process of Scientific Inquiry**

A general look at the process

- Observations come first, because we notice a possible relationship in our environment.
- We ask a question about it. . . etc.
- Each step has recursive arrows because each step includes revision of the steps previous.

**Causal questions / Hypotheses****Causal Question (asking about a relationship)**

How could . . (something changing) . . affect . . the value of some other variable

i.e. How could the amount of CO₂ in the atmosphere affect the average temperature on the earth?

Hypothesis

If directional change of variable, occurs then . . (direction of dependent variable) change, because. . . (possible reason)

Methods

Controls

Repeat

HYPOTHESES

- testable statements about the observable universe
- verifiable OR falsifiable
- statements that are not falsifiable are not scientific hypotheses (eg. "There is a God." and other moral or religious claims and value judgements)

Specific vs. General Hypotheses

- specific: eg. "The sun will rise in the east tomorrow morning."
 - too specific, easily verifiable, relatively unimportant
- general: eg. "The sun will rise in the east EVERY morning."
 - can be tested in the same way as first one
 - note that a single failure of the sun to rise will falsify the hypothesis, but no finite number of sunrises would be sufficient to verify the hypothesis for all time
 - the type of hypothesis usually examined by science is absolutely falsifiable, but not absolutely verifiable

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So... what is science????

1. Science is a very human endeavour (the good the bad and ugly are all there);
 - Sociology, politics, psychology, and similar aspects of human nature all have a profound influence on how science is conducted.
2. Science follows certain rules and guidelines, but these are discipline specific.
 - The scientific method (i.e. hypotheses are formulated from observations and questions, and theories develop from these hypotheses), is not the paradigm that scientific inquiry must always follow, but it often is the best objective procedure.
3. to make clear when science is an issue is the difference between fact and opinion.
 - "Fact" in a scientific context is a generally accepted reality (but still open to scientific inquiry. This is opposed to an absolute truth, which is not open to inquiry, and hence not a part of science).
 - Hypotheses and theories are generally based on objective inferences, unlike opinions, which are generally based on subjective influences.
 - Opinions are neither fact nor theory.

Conclusion**A Definition of Science**

- A method of investigation based on the testing of falsifiable hypotheses that are generalizations that can be falsified but never absolutely verified.
- This makes scientific statements tentative and subject to possible falsification by the next test.
- Repeated exposure of hypotheses to possible falsification increases our confidence in these hypotheses when they are not falsified, but no amount of testing can guarantee absolute truth.